Arterial Spin Labeling Perfusion Imaging of the Kidneys using Prospective Navigators and Slice Following

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Introduction

Arterial spin labeling is a subtraction technique and thus susceptible to motion artifacts induced by respiration. Nevertheless, several studies have successfully acquired perfusion images of the kidneys using spin labeling [1, 2]. However, subjects had to adapt their respiration pattern to the sequence, which is impossible in clinical use. We implemented a navigator controlled balanced SSFP sequence using prospective navigator acquisition to adapt the position of the acquired slice according to the diaphragm shift. It is shown that using this technique 100% gating efficiency can be reached without subtraction errors.

Methods

All experiments were performed on a 1.5 T system (Magnetom Sonata, Siemens). Spin labeling was implemented using the FAIR labeling technique [3] using an inversion time of 1.3 s and 3 s delay between subsequent pulses. The coronal slice was positioned as shown in figure 1. For readout, a segmented centric reordered balanced SSFP sequence with $\alpha/2$-preparation was used. The parameters were: 65 lines per inversion, bandwidth 400Hz/pixel, asymmetric readout with TE 1.8 ms and TR 4 ms, 300 mm FOV, 128 Matrix with 52% phase oversampling, 6 mm slice thickness and 50° flip angle. A 2D excitation with 30° flip angle was used to acquire 1D profiles through the diaphragm before each data acquisition. To determine the tracking factor for inplane slice following with prospective navigators, a 10 s navigator gated segmented FLASH sequence was used to acquire coronal images at 0, 5 and 10 mm diaphragm shift. Acquisitions with and without slice following were performed using 10 averages respectively, all acquired data was accepted.

Results and Discussion

For the kidneys, an average tracking factor of 0.7 was determined. Figure 2 shows the images obtained with and without tracking, both acquisitions had 100% scan efficiency and took 3 minutes. Without respiratory control (left), respiratory artifacts appear in the images. With inplane slice following, the images are free of breathing artifacts in the kidneys (right). Coronal slice orientation is crucial for successful motion compensation. As the kidneys move in head-feet direction solely, the slice selective inversion always coincides with the slice excitation irrespective of the tracking. Use of the head-feet direction for readout minimizes phase errors caused by imperfect motion compensation. When a different slice orientation is desired, a navigator would have to be measured before the labeling pulse as well, with application of the same slice following for the inversion slab. With the presented technique, spin labeling perfusion imaging of the kidneys is feasible in a clinical setting. As a future improvement, acquisition of 10 partitions in 3D mode instead of tenfold averaging would increase the coverage of the acquisition while preserving the SNR.

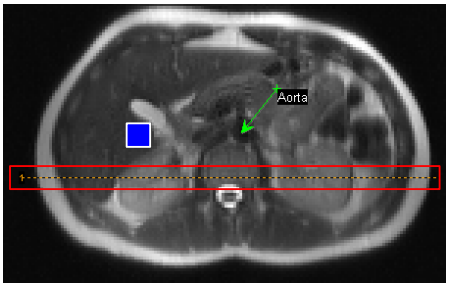

Figure 1: Slice positioning.
A 15 mm inversion slab (red) covered the 6 mm slice (orange), but not the aorta or renal arteries. A 15 x 15 mm pencil beam navigator (blue) was positioned on the right diaphragm.

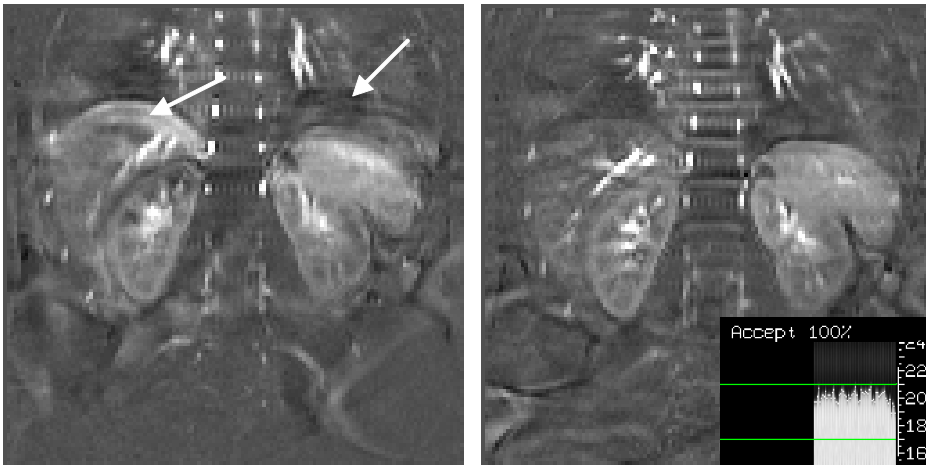

Figure 2: Perfusion images acquired during free breathing.
Left: without navigator correction, motion artefacts appear (arrows) and the kidneys are blurred. Right: The navigator signal shows considerable diaphragm shift during the acquisition. The perfusion image acquired using appropriate head-feet slice tracking shows no blurring in the kidneys but in the stationary structures like the spine.

References

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[3] Kim SG, Magn Reson Med. 1995 Sep;34(3):293-301.